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75 YEARS OF OIL AND GAS EXPLORATION AND DEVELOPMENT IN ALBERTA

1883 - 1958

Background Information

by

C. W. JACKMAN
Alberta
DEPARTMENT OF MINES AND MINERALS

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The history of the oil and gas industry in Alberta dates back to the last century when construction of the Canadian Pacific Railway necessitated a search for water along the right of way in south-eastern Alberta. A well drilled near the present hamlet of Alderson (formerly Longevin) in 1883 to supply water struck gas at a depth of 1,155 feet. Other gas wells were drilled in the area, but no field development took place.

The first commercial development of a field occurred at Medicine Hat where gas was discovered in 1890 when a hole was put down in search of coal. The town officials took up the matter with the C.P.R. who loaned the town equipment to drill a deeper well. The well drilled by the town as a result of this arrangement was completed in 1904 as a producer from the sand that is the main reservoir of the field at the present time. The offer to loan the equipment to the town to drill its own well also led to the development of the first natural gas utility system in Western Canada.

A discovery of oil or gas is a matter of importance not only to the operator who made the discovery, but also to the owner of the mineral rights.

The ownership of the mineral rights is a matter that is closely associated with the history of Western Canada. In 1670 Charles II granted a charter to a group headed by Prince Rupert to be known as the Hudson's Bay Company, giving it title to territory which became known as Rupert's Land. It included all lands watered by streams flowing into Hudson's Bay. Shortly after confederation the surveyors began to run

lines through what is now Manitoba. This indication that prairie settlement was at hand stirred Metis to the point of revolt. Federal authorities surmised that fur trade interests were involved and drafted a deed of surrender to Her Majesty of Rupert's Land and adjoining territories. The surrender was effective July 5, 1869. In return the Company kept its posts, trading rights and received £300,000 and the Company could at any time within fifty years after acceptance of the surrender, claim in any township within the fertile belt in which land is set out for settlement,.grants of land not exceeding one-twentieth of the land so set out. The fertile belt was described as the area between the United States border on the south, the North Saskatchewan River on the north, the Rocky Mountains to the west and Lake Winnipeg and the Lake of the Woods on the east.

When the Canadian Pacific Railway was raising capital to finance construction it needed some assets to back its bonds. To facilitate construction, the Government granted the Company all the odd-numbered sections except 11 and 29, in each township for 25 miles on both sides of the right of way. The Calgary and Edmonton Corporation and other railway companies which undertook construction before the turn of the century received similar grants. If the designated land was previously granted, then the railway could take land outside the belt along the right of way. As a consequence, we find C.P.R. land many miles from a C.P.R. track. Mineral rights went with all these grants.

The Governor General in Council, on the 31st day of October, 1887, approved a recommendation that a clause be inserted in all patents from

the Crown for lands in the Northwest Territories situated west of the third meridian, reserving to Her Majesty, Her Successors and Assigns forever, all mines and minerals which may be found to exist within, upon, or under such lands together with full power to work the same, and for this purpose to enter upon and use and occupy the said lands or as much thereof and to such an extent as may be necessary for the effectual working of such minerals. An exception was made of lands of which disposition had already been made for valuable consideration.

In 1930, administration of the resources excepting those in National Parks and Indian Reservations, was transferred from the Federal Government to the Governments of the Prairie Provinces.

At first the railways which had a total of 23,000,000 acres of fertile land in Western Canada sold it freely with all the mineral rights, except coal. This, until 1902, was their only concern. The Hudson's Bay Company sold land including mineral rights, until 1908. After 1902, the railways began to make reservations. Where previously they had kept only coal rights, they began to reserve coal and petroleum. Later railway property sales were made with coal, petroleum and natural gas rights reserved. Finally they reserved all mineral rights. These changes of policy have left some difficulties and there has been litigation over what these rights actually involve. When the Hudson's Bay Company decided to reserve mineral rights in 1908, it immediately began to reserve all mineral rights.

Alberta mineral holdings of the company in 1930 totalled 2,400,000 acres.

As a consequence, the Crown in Alberta either in the right of the

Province or Canada, owns approximately 87 percent of the mineral rights with the Federal portion consisting of those rights in Indian reserves and national parks. Less than four percent is in the hands of individuals and the remainder is held by private companies.

The plains area of all Western Canada has one geological characteristic which distinguishes it from the plains of the Southern United States. The characteristic is that most of the surface consists of a thick mantle of glacial till. This till and the eroding action of the glaciers which produced it, have eliminated almost all surface evidence of structures or folds in the underlying sedimentaries which might provide a trap for migrating oil or gas. The only exceptions are river valleys where sedimentary outcrops occur and a few ranges of hills such as the Cypress Hills and the Swan Hills which have resisted erosion. As a result, most early drilling locations were selected on the basis of mineral ownership, accessibility and other considerations, rather than the geologic prospects.

In spite of the haphazard selection of drilling locations, several significant discoveries were made. The Bow Island gas field was the original source of gas for Calgary and Lethbridge. The discovery of gas at Viking led to the development of a field that for many years was the only source of supply for Edmonton and other Central Alberta communities. The first crude oil discovery of commercial significance to be made on the Alberta plains was at Wainwright in 1925. This reservoir contains a heavy gravity crude. Similar discoveries were made later at Vermilion and Lloydminster.

It was the exposure of an oil impregnated sand along the lower Athabasca River that first excited men's minds about the possibility of finding oil under the western plains. These deposits were noted by early explorers as for back as 1779. They were investigated by R. G. McConnell of the Geological Survey in 1887 and have since been the subject of much investigation and research.

This deposit was erroneously called "Tar Sands" because the oil on exposure at the surface becomes hard and asphaltic in appearance. The sands are currently known as Bituminous Sands and the hydrocarbon which they contain is crude oil. If the oil had not been exposed at the surface and had been found by conventional drilling, it would have been reported as a heavy gravity* oil found in the McMurray Formation.

* The term "gravity" as applied to oil on this continent is usually a reference to a scale evolved by the American Petroleum Institute and which is graduated in degrees A.P.I. Oil which has a specific gravity of 1.0 is 10° A.P.I. An example is the heaviest Lloydminster crude. As the specific gravity decreases, the degrees A.P.I. increase. Heavy oils are those with a gravity of up to 20° A.P.I. Medium oils are from 20° to 30° A.P.I., and light oils have a gravity of 30° A.P.I., and over. Light oils are more valuable because of the relatively high gasoline yield. Heavy crudes normally have low gasoline yields and a high percentage of asphaltic ends. Crude oil prices are based mainly on the gasoline yield per barrel. Generally speaking, the greater the heat and pressure to which an oil has been subjected in the reservoir, the lighter it will be.

Geologists of the Geological Survey surmised that liquid phase oil might exist down dip from the surface exposure. The sites selected for drilling were near gas seepages at Pelican Rapids on the Athabasca River and Victoria (Pekan) on the Saskatchewan River. The well at Pelican discovered gas at 820 feet and blew out of control for a number of years. The other hole was abandoned.

It was in the foothills of the southwest that the Alberta oil industry actually got its start. In this area of folded and faulted sedimentary rocks, structures are sometimes discernable at the surface and seepages have been observed. The seepages attracted the early operator. The first oil production was obtained at a hole drilled near a seepage in the vicinity of Waterton National Park. It found an isolated pool of oil in 1902 and produced from it for a short time.

A rancher hauling coal between Turner Valley and Okatoks in 1911 noticed some gas seepage along Sheep Creek. Analysis of the gas determined that it was of petroleum origin. A well known as the Dingman well after the man who had charge of the drilling, was put down and completed in 1914 as a gas producer from a sand of Cretaceous Age. The wet gas contained a very light oil or natural gasoline which could be used as a moter fuel without any processing.

The original syndicate, Calgary Petroleum Products Company was re-financed and re-organized as the Royalite Oil Company which started drilling a new well, Royalite No. 4 in September, 1922. This well was drilled into the limestone formations underlying the Cretaceous sand and encountered a large flow of wet gas. The well blew out of control

and caught fire, but was eventually put on steady production. Source of the gas was the Rundle Limestone of Mississippian Age. The gas contained a large amount of naphtha which was separated from the gas and sold. The residual gas was burned for lack of markets.

This was the first of many wells drilled into the Turner Valley gas cap in the next twelve years for the recovery of naphtha. Most of the gas produced was excess to requirements of the available market and was flared. It is estimated that about one trillion cubic feet were wasted in this manner. It was not until oil was discovered lower down the structure that a reduction in gas production took place.

The discovery of crude oil was made in 1936 when a well was drilled in the southwest flank of the field. Selection of the location was occasioned by the discoloration of the naphtha in some of the wells. This discoloration coincided with a decline in the field pressure. It was reasoned that the discoloration was due to an influx of crude oil which was migrating up-dip as the gas pressure declined.

Completion of the discovery well led to another extensive drilling program. Oil production soon outgrew the available market and the principal purchaser, Imperial Oil Limited, set up a system of prorationing the market amoung the producers. The Provincial Government entered the resulting controversy and by statute established The Petroleum and Natural Gas Conservation Board in 1938. The Board prorationed the market among the producers by setting a monthly quota for each well. Quotas were based on the drainage from a parcel of 40 acres, bottom hole pressure, the gas-oil ratio and the rate of flow through a choke during

test. Operators were penalized for having more than one well on a 40 acre spacing unit.

This first rigid application of conservation to Turner Valley development and production was the start of an oil and gas conservation program which was to regulate all future drilling and production in the Province. It came too late for Turner Valley, however. It is estimated that wasteful production prior to 1938 so reduced the pool pressure that less than 20% of the oil will be produced. This effect was aggravated by producing at maximum rates during the war years when production allowables were enlarged by the Oil Controller for Canada.

The depletion of the Turner Valley reservoir during the war had another result which threatened the economy of the whole Province. Light oil production began a decline which made oil imports a likely prospect, unless major new discoveries were made. During the war years and the years immediately preceeding the war, small discoveries of both oil and gas had been made. Most of the oil was a heavy asphaltic product in small pools. A few of the discoveries had commercial significance. Among these were Taber, Conrad, Del Bonita and Princess. Princess was unique, in that it was the first discovery of a limestone oil reservoir under the plains. Some of the larger oil companies undertook an extensive natural gas exploration and development program, in order to be prepared to synthesize gasoline from natural gas. The McColl-Frontenac and Union Oil of California team delineated a large natural gas field in the Pakowki Lake area,

southwest of Medicine Hat. Imperial Oil Limited carried out an extensive drilling program which extended the Viking-Kinsella field and discovered new gas reserves south of Provost.

The most important discovery of the period was made in 1944 by Shell Oil Company at Jumping Pound, twenty miles west of Calgary. Wet gas was found in the Rundle Formation at over 10,000 feet. Other exploration work was undertaken in various parts of the foothill belt. Home Oil Company Limited, found wet gas in the Brazeau area, but no oil was found at any of the exploratory drilling operations.

The oil shortage during the war turned attention to the bituminous sands as a possible source of crude oil products. The search for a feasible method of separating the oil from the sand was started by the Research Council of Alberta in 1920. Three private concerns also undertook experimental operations to determine if oil could be extracted on a commercial basis. The first of these, the International Bitumen Company, which erected a small plant at Bitumount and McMurray Bitumen and Oil Company which had a plant at Draper. Abasand Oils Limited, later erected a plant a few miles from McMurray. During the war this plant was taken over by the Federal Government for experimental purposes. The plant was destroyed by fire in 1945 and work was continued by the Mines Branch at Ottawa.

In 1944 the Alberta Government decided to build an experimental plant for the extraction and refining of oil from the bituminous sands. The plant was completed at Bitumount in 1948. Some test runs were made but operations were discontinued in 1949.

Meanwhile a series of oil discoveries in the Edmonton area ended the concern about a shortage of oil in Western Canada and marked the beginning of a radical change in the economic life of Alberta.

The first large scale use of geophysical equipment as a method of exploring for oil in Alberta came in the early years of the war. The seismograph is the instrument on which the most reliance was placed as a means of locating possible reservoirs. Use of the seismograph makes up for the lack of geological outcrops on the surface of the plains. Geophysicists took their place alongside geologists when drilling locations were being selected.

A location selected on the basis of seismic information led to the drilling of Imperial Leduc No. 1 and the discovery of a major light oil field in the plains area of Alberta. This first Leduc well was spudded late in 1946. Early in 1947 it encountered Limestone of Devonian Age which was identified as the D1 and later called the Wabamun Formation. After beds of shale and anhydrite had been penetrated, a second limestone formation was encountered which was called D2, and later renamed the Nisku Formation. It was this formation that held the light gravity oil.

In the second well the D2 zone was non-productive and drilling was continued through a shale formation and below the shale, a third limestone or dolomite was encountered. This formation, to become famous as the D3, was later called the Leduc Formation. The well was completed as a producer of 39° A.P.I. oil from the D3 zone.

Subsequent drilling proved that Leduc was really two fields, one

300 feet above the other. The D3 is the major reservoir of the two. It is an organic reef formation which constitutes a ridge or mound of limited dimensions and irregular shape that was formed in shallow waters. The core, which is the reef proper, is a complex mass of organic materials that was built up from a wide base on the sea floor. The upper part of it is extremely porous and an excellent oil reservoir. When the reef-building activities of the corals and other organisms ceased, the deposition of shale sealed the reef with its content of sea water in the pores. When hydrocarbons were formed from decomposition of organic matter in the reef and surrounding sediments, oil and natural gas rose to the top of the reef displacing the water downward. Oil with gas in solution formed a layer above the water. Excess gas gathered in a bubble or gas cap above the oil.

The shale deposition around and over the reef tended to be compressed except where the pressure was resisted by the rigid nature of the reef. This caused a draping effect in formations above the reef and resulted in the anomaly or structure detected by the seismograph crew. It also created reservoir conditions that resulted in oil and gas accumulations in overlying formations including the D2.

The discovery of a two zone oil field in an oil deficient area brought an exciting promise. It seemed reasonable to expect that more wells could find production in the first reef and if there was one reef, there should be more. Oil concerns already established in the Province began development of acreage held in the area and many new organizations were formed to develop leases obtained after the

original discovery. As most of the new concerns had little geological or geophysical information to guide them, acreage was selected on the basis of availability rather than proximity to either of the discovery wells, since the size and shape of the field were unknown. The only method of delineating an oil field is by drilling. Development at Leduc was on the basis of forty acre well spacing for each reservoir, and within a year after the discovery it was well established that a field of major proportions had been discovered.

While one field was being developed, geophysical crews were busy searching for new anomalies to drill. Many wildcats were drilled in the area in the year following the Leduc discovery of which the first successful one was at Woodbend, eight miles north of the Leduc discovery. The woodbend well extended the D3 zone northward from the Leduc discovery in February, 1948.

The first discovery of a distinct field was the result of exploration by Gulf Oil Corporation in Southern Alberta. In April, 1948, Gulf discovered an immense wet gas reservoir south of Pincher Creek at 11,800 feet. This discovery uncovered the first major gas reserve not immediately required for an Alberta market and initiated schemes to export surplus gas from the Province.

Reefs were found by a number of exploration wells in the Edmonton area but until late in 1948, none was found that contained anything but salt water. In October, 1948, a well was put on production at Redwater by Imperial Oil Limited. This well confirmed the existence of a chain of oil bearing reefs and made land holdings in Alberta sedimentary basin

a "must" for every major oil company. Participation by a large number of operators is possible due to the use of the competitive rather than the concession type of prospecting and leasing procedures which prevents monopoly control of large areas by one operator or group of operators.

In 1949 the development of the Redwater field raised Alberta's crude oil production capacity* beyond the requirements of the available market. All movements out of the Edmonton area were by rail and the relatively high charges restricted the market area to the prairies. This necessitated prorationing production from the new fields to match the available market in order to ensure that each producer had a fair share of that market.

Provision for new markets was made by the construction of a pipe line from Edmonton to Superior, Wisconsin. From Superior tankers carried oil to refineries at Sarnia and Toronto. This pipe line was completed in December, 1950 and the first oil was delivered by tanker at Sarnia the following spring. Crude oil prices in Alberta were adjusted to meet the competition of crude from the United States for the Ontario market.

* In order to prevent waste the Oil and Gas Conservation Board regulates all production practices. Unless the rate of oil production from a pool is regulated according to its production capacity, an unnecessarily large proportion of the oil will be left in the reservoir. To prevent this, the Board determines a Maximum Permissive Rate (M.P.R.) for each reservoir. The M.P.R. is based on various reservoir factors and characteristics. When the production capacity is in excess of the market demand, a method of prorationing production in order to divide the available market equitably among the producers was divised.

In 1953 a pipe line was completed from Edmonton to Vancouver with a branch extending to the State of Washington where refineries were being constructed at Ferndale and at Anacortes. In the same year the Interprovincial line was extended from Superior to Sarnia and later to Toronto.

In the meantime, a succession of oil discoveries in Alberta were giving the Province a steadily rising production potential. While most of the discoveries were made in the Edmonton area, extensive exploration programs resulted in substantial oil discoveries being made as far south as Drumheller and as far north as Sturgeon Lake, by the end of 1953. Most of the discoveries were made by holes drilled in search of the reef which is the source of oil at Leduc and Redwater, but the extensive drilling also led to the discovery of light crude in formations above the Devonian reefs.

Several substantial pools were found in sands of Lower Cretaceous age. The Cardium sand, an Upper Cretaceous formation which had not previously been seriously considered as a potential oil reservoir, was to provide the largest oil field in areal extent yet found in North America. An exploration hole near Drayton Valley was drilled to completion depth of over 9,000 feet in 1953 without finding any evidence that either oil or gas were present in commercial quantities. When the hole was being abandoned each formation was carefully tested before it was sealed off. The test of the Cardium sand indicated the presence of oil

but the sand was so impermeable that the oil could not be recovered in any quantity. To increase the permeability of the reservoir what was then a new technique was employed. Oil and sand were injected into the hole under tremendous pressure. This pressure opened cracks in the formation. The injected oil was forced into these cracks and carried grains of sand with it. When the pressure was released, the injected oil flowed out and left the grains of sand which kept the cracks open. This permitted the formation oil to gain access to the well which was completed as the first producer of what is now the Pembina field in July of that year.

Subsequent drilling has developed a pool with an area of over 700 square miles. The pay thickness is 15 to 20 feet. The reservoir has no water below the oil and no gas cap over it. Solution gas pressure supplies the only natural energy available to move the oil through the reservoir sand. Due to high resistance of the sand to the flow of oil (low permeability) production problems have developed. In the early production life of an average Pembina well it takes less than 1,000 cubic feet of gas to produce one barrel of oil. As production continues, it takes increasingly larger amounts of gas to move a barrel of oil through the reservoir to the well bore. A careful check is kept on the production history of each well by Oil and Gas Conservation Board field staff and when the gas-oil ratio reaches a point at which it is considered that the amount of gas required to produce a barrel of oil represents a waste of reservoir energy, the operator is penalized by having the M.P.R. of the well lowered.

Continued production under these conditions results in higher production costs for the well and means that the dissipation of reservoir energy is out of proportion to the amount of oil produced. When the energy is completely dissipated, no more oil will be produced and all but a small fraction may be left in the reservoir.

This problem has been faced in a number of Alberta fields, but the immense reserves of oil in the Pembina reservoir makes the situation in that field one of particular interest. To compensate for the loss of natural energy, artificial energy is introduced to the reservoir in the form of water or gas under pressure to force more oil to the well bores. This process is known as "secondary recovery" to distinguish it from production obtained by the use of natural energy alone, or "primary recovery".

In the Pembina field several methods have been tried to determine which is the most efficient. These include water injection through alternate wells into the oil zone to force the oil toward producing wells. In other parts of the field gas is being injected. Experimental work is being conducted with the injection of liquified propane and butane into the reservoir. Production allowables of a well used for injection is transferred to producing wells around it. Where it can be demonstrated that additional oil recovery can be attributed to the scheme, the M.P.R. of wells is increased to defray capital costs and operating expenses involved in the secondary recovery program.

One of the more difficult problems with which to contend in oil production is that of the solution gas unavoidably released in the course

of oil production operations. Gas gathering systems and processing plants represent a large capital expenditure. Gas conservation in an oil field is usually undertaken when it appears that the cost of the project can be repaid over the producing life of the field and yield a reasonable rate of return on the investment.

After being processed to remove natural gasoline, butane, propane and sulphur, the residue dry gas is marketed or stored. Natural gasoline is used by refineries for blending with gasoline produced from crude oil. Propane and butane are utilized as fuels, raw materials for petrochemical industries and in secondary recovery of oil. Due to seasonal variations in demand and supply, it is very important that storage facilities for the liquified gases be made available. Such facilities are being provided in central Alberta near Hughenden where a salt deposit at a depth of approximately 4,500 feet has had a cavity formed in it by injection of fresh water to produce brine. The brine is forced to the surface by water circulation through two pipes, one inside the other. When the cavity is sufficiently large surface installations will be used to pump the liquid gases down the outside pipe, forcing water under pressure out through the other. When gas is required the reverse procedure will produce it from the pipe previously used for gas injection.

The dry gas which is used as domestic, commercial and industrial fuel usually consists almost entirely of methane, the lightest component of natural gas. Gas from some reservoirs may contain significant amounts of ethane, a compound between methane and propane in physical and chemical properties. It occurs in relatively large quantities in Leduc

gas and is extracted in a plant near Edmonton for production of the plastic known as polythene.

Hydrogen sulphide is a component of gas in many of the Province's fields. Because it is a highly poisonous gas which also corrodes metal, it must be removed before the gas can be processed or used. If the amount of hydrogen sulphide recovered at a plant is sufficiently low to be harmless, it may be vented to the atmosphere, otherwise it will be processed for the recovery of elemental sulphur.

The extensive oil exploration program which began with the Leduc discovery resulted in a large number of gas discoveries which were incidental to the search for oil. If gas was encountered during the drilling of a well, the drilling would be continued to the intended completion depth. If it failed to find oil and the gas flow had indicated a gas discovery of commercial importance, the hole would be cased and suspended as a potential gas well. Although some operators undertook to develop gas reserves, most of the isolated discoveries failed to encourage development work due to lack of gas markets.

Until the end of 1950, all Alberta gas marketed was sold within the Province. Small quantities of gas started going to Dawson Creek, British Columbia, in 1950 and to Montana in 1952. The lack of export of larger quantities was due to the policy of having proven reserves adequate to meet the Province's requirements for a period of thirty years, before a permit for the export of additional reserves would be granted. In 1953 a permit was approved, allocating surplus gas in the

Peace river area for transmission to south-western British Columbia and north-western United States. This project of Westcoast Transmission Company Limited went into operation in 1957.

In 1954 the Oil and Gas Conservation Board reported a surplus of gas adequate to supply a large market area extending east as far as Montreal and south into the United States. A permit was issued to Trans-Canada Pipe Line Limited to supply this market. Gas was supplying the market area as far east as Winnipeg late in 1957 and reached the Montreal market area at the end of October, 1958. The gas for this project is gathered by The Alberta Gas Truck Line Company Limited which is constructing a network of feeder lines that in addition to delivering gas to Trans-Canada at the Saskatchewan border, supplies gas to Alberta residents within economic reach of the Company's pipe line.

The expansion of activities of the operators engaged in the search for oil and gas has involved almost all of the 220,000 square miles of the sedimentary basin of the Province. Exploration operations beyond the edges of settled areas are handicapped by the presence of muskeg in either scattered patches or large areas covering many square miles.

Muskeg, a Chipewyan Indian word meaning "grassy swamp" is used to describe a wide variety of organic material which forms the surface of much of the unsettled areas in the north and west of the Province. The seasonal advance and retreat of oil exploration crews working in these areas is caused by the physical impossibility of moving equipment over muskeg which is not frozen. The period during which

exploration operations involving wheeled vehicles may be conducted is determined by the length of the period during which the muskeg is securely frozen. Normally freeze-up comes in November, but if a heavy snow preceeds the first severe cold weather the snow cover may hold the heat in the muskeg and delay extensive exploration until January. Crews are usually out by the end of March.

Muskeg areas frequently contain bush and stands of timber and in order to conduct geophysical operations on a systematic basis, operators have to cut trails to provide access for the equipment.

When exploration drilling is being undertaken, a road is required to move drilling equipment in and out and move supplies over while drilling is in progress. If the projected depth is no more than 7,000 feet it is possible that drilling operations may be completed in one winter season. If it is deeper, operations will either be suspended with the arrival of the spring break-up or supplied over an all-weather road. Frequently for a test to a depth of over 10,000 feet, an all-weather road is constructed to the site so that drilling operations may continue without interruption. If production is obtained and field development undertaken, a network of permanent roads will be required. Road costs in the Pembina field, which is partly in a settled area, were six million dollars to the end of 1958.

In the foothills and mountains there are additional difficulties in the form of mountainous terrain, fast flowing streams and deeply incised valleys. Deep snow in winter restricts exploration operations to late summer. These conditions have greatly lengthened the time

required to complete seismic surveys of the western portions of the Province. Drilling operations involving depths of up to 15,000 feet have frequently required over a year to complete a single hole.

The search for oil and gas in these areas has been rewarded with the discovery of large reserves of both oil and gas. The first of these was the discovery of oil in the woodbend reef at Sturgeon Lake in 1953. At Red Earth 120 miles north-east of Peace River, oil was found in the Granite Wash, a coarse sand found immediately above the Pre-Cambrian Granite. In the Swan Hills three oil fields are being developed following the discovery of oil in the Beaverhill Lake Formation. In the wooded country west of Whitecourt a number of significant gas discoveries have been made. The intensive exploratory drilling in the foothills and adjacent areas has resulted in a number of important discoveries reaching from the international border to a point near Grande Prairie. Among these discoveries is the Berland River well north of Entrance which has a calculated open flow potential of 1.5 billion cubic feet per day from the Woodbend Formation, at a depth of over 12,000 feet. This is the largest potential ever reported for a gas well.

Except for weather and terrain conditions the only likely limiting factor on oil and gas exploration and development in Alberta for some years will be the provision of markets. It will require 20,000 exploratory holes to effectively explore 200,000 square miles of surface under which oil and gas may be found. At the end of 1958 approximately 4,500 of these holes had been drilled. Exploratory

drilling has averaged over 350 completions per year from 1952 through 1958.

One of the most obvious and important results of the oil and gas discoveries and the subsequent development of these resources has been the rapid increase in Alberta's population. A second result has been the provision of a cheap supply of raw materials for petrochemical industries. A third result which is less obvious but equally important, is that fuel prices have remained relatively stable in a period of inflation and rising living costs.

Industries which utilize by-products of oil refining and gas processing for raw materials have been attracted by low cost raw materials and power and the growing population as a source of labor. Other industries have been attracted by the requirements for oil and gas field equipment.

Ammonia has been produced in Calgary by Consolidated Mining and Smelting Company of Canada Limited, since the early years of the war. The plant utilizes the methane from natural gas to combine with atmospheric nitrogen for the production of ammonia. The ammonia is used to manufacture explosives and fertilizer.

Canadian Industries Limited utilize the high ethane content of Leduc gas to produce polythene (polyethylene) at Edmonton by converting the ethane to ethylene and polymerizing it at high pressure.

The largest addition to Alberta's chemical industry was made by the Canadian Chemical and Cellulose Company Limited with the construction of a plant at Edmonton to use oil refinery gas and propane

and butane from gas processing plants in the production of alcohols, ketones, aldehydes, acetates and other industrial chemicals. The principal product is cellulose acetate which is marketed as filament yarn and staple fibre.

Sherritt Gordon Mines Ltd. produce ammonia from gas to treat concentrates from the Company's mine at Lynn Lake, Manitoba, by the ammonia-leach process. In addition to nickel, cobalt and copper concentrate, the plant at Fort Saskatchewan produces ammonium sulphate fertilizer as a by-product of plant operation.

Inland Chemicals Canada Ltd. has a sulphuric acid plant at Ft. Saskatchewan which obtains elemental sulphur from gas processing plants. The principal market for the acid is the uranium industry of Northern Saskatchewan.

At Medicine Hat, Northwest Nitro-Chemical Company combine ammonia from natural gas with phosphate rock from Montana to produce ammonium phosphate fertilizer.

The first salt production in Alberta was obtained by a plant at Waterways in 1938. As a result of oil exploration it was found that a large part of eastern Alberta was underlaid by a salt deposit. As a result of these discoveries a second plant started salt production near Lindbergh in 1948 where salt deposits aggregating 1,000 feet in thickness had been found.

A new industry was started at Duvernay where a plant was completed by Western Minerals Limited to process common salt for the production of chlorine and caustic soda.

The inception of the large scale oil and gas development program greatly increased the demand for cement. This increase in market requirements induced foreign capital to organize the Inland Cement Company Limited, which erected a plant at Edmonton.

The manufacturing of plastic products was undertaken by Polychemical Industries Limited in a plant constructed near Edmonton. Included in the products is polythene pipe which has a number of industrial applications.

The demand for steel and the high freight rates on imported steel products led to the construction of two plants at Edmonton. Premier Steel Mills Limited produces steel for building construction. Alberta Phoenix Tube and Pipe Limited rolls steel for pipe line construction.

New industries have been established to provide equipment for oil and gas exploration and development operations. A number of firms have undertaken the manufacture of oil field hauling equipment with special adaption for muskeg conditions.

Drilling operations involve the use of a fluid to circulate through the bit at the bottom of the hole. The principal ingredient of this fluid is normally Bentonite which is a clay formed by the chemical alteration of volcanic ash. Its special quality is its tendency to absorb large quantities of water and to expand greatly in the process. There are many bentonite deposits in Alberta but until 1958, no deposit had been found in which the bentonite had the desired qualities and which was large enough to justify commercial

development. The first large-scale production of bentonite started at Rosalind in 1959.

Other products which may be produced in the near future include urea, ethylene glycol and butadiene.

Urea is an organic compound used in medicine, explosive manufacture and fertilizers. One of its most important applications is to keep streets free of ice and snow in winter. For this purpose it is preferable to the chlorides commonly used, in that it does not produce rust. Ethylene glycol is used in explosives, as a anti-freeze and as a solvent for waxes and resins.

Butadiene is important as the source of synthetic rubber. It is formed from butylene in waste refinery gases or from butane.

Exploratory drilling for oil and gas in the Clear Hills area north of Hines Creek led to the discovery of large deposits of iron carbonate (Siderite) which contain over 30 percent iron. Investigation of the deposit has determined that it contains over 1.5 billion tons of ore. Establishment of an iron and steel industry awaits the development of a sufficiently large market.

Continuous research with the multitude of chemical compounds that can be obtained from hydrocarbons and the uses that can be made of them are assurance that the present chemical development in Alberta is but the nucleus of a much more substantial chemical industry.